NASA
National Aeronautics and
Space Administration

FREEDOM

SPACE STATION FREEDOM
ADVANCED DEVELOPMENT PROGRAM
OVERVIEW

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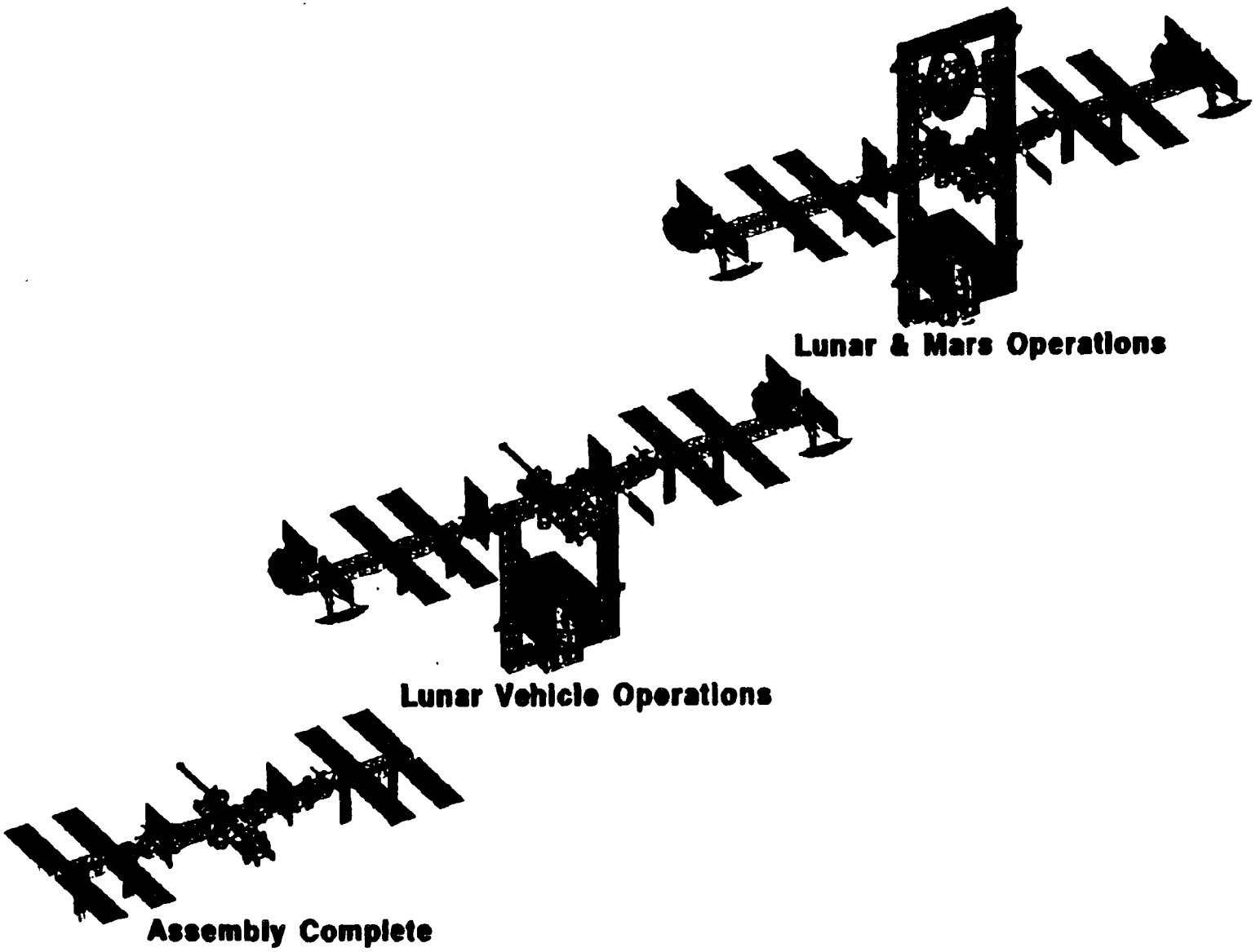
SPACE STATION FREEDOM EVOLUTION

- *Freedom is a permanent facility:*
  - -- Upgrades and configuration changes will take place on-orbit
- *During the operational life of the Space Station:*
  - -- National priorities will change
  - -- User needs and mission requirements will change
  - -- Technology will evolve and components will become obsolete

SPACE STATION FREEDOM – EVOLUTION FOR HUMAN EXPLORATION



ADVANCED DEVELOPMENT PROGRAM INTRODUCTION AND OVERVIEW

FREEDOM

- *Background*
  - -- Transition Definition Program established in FY 1988 to conduct studies and advanced development to ensure baseline Station can evolve
  - -- Modest budget authority placed at Level I as recommended by Phillips Committee
- *Two major elements within Transition Definition:*
  - -- Advanced System Studies
    - Define Station capabilities required to support future needs
  - -- Advanced Development
    - Improve productivity & reduce operations costs of baseline systems

SPACE STATION FREEDOM
ADVANCED DEVELOPMENT PROGRAM

- *Objectives*
  - -- Enhanced baseline Space Station Freedom capabilities
    - Improve productivity & reliability
    - Reduce operations costs
    - Prevent technological obsolescence
  - -- Enable Space Station Freedom evolution
- *Products*
  - -- "Engineering" fidelity demonstrations, evaluations
  - -- Detailed requirements, performance specifications
  - -- Mature technology, tools, applications

ADVANCED DEVELOPMENT PROGRAM PLANNING

- *Advanced Development Task Force held 2/88, LaRC*
  - -- Levels I-III, Code R, Center personnel participated
  - -- Optimizing Productivity selected as theme
  - -- Knowledge-Based Systems (KBS) targeted for FY89 Program

- *Advanced Automation Study completed 5/88*
  - -- Developed short list of baseline candidates
  - -- Analyzed evolution of KBS applications, tools
  - -- Identified high payoff KBS advanced development areas

- *Review of SSFP Advanced Automation Development Capabilities 12/88*
  - -- Provided overview of testbeds with KBS applications
  - -- Described existing/planned operational & support capabilities
  - -- Identified evolution issues and strategies

FACTORS POINTING TO AUTOMATION & ROBOTICS (A&R)

FREEDOM

- *Space Station has a 30 year operational life*
  - -- Operations costs, reliability are important concerns
  - -- Incorporation of new technology essential
- *Crew is most scarce resource*
  - -- Productivity is crucial in meeting assembly, user, and servicing requirements
- *Evolution mission scenarios are crew-intensive*
  - -- Science missions will grow & increase demand for crew time
  - -- On-orbit assembly, checkout, launch of Lunar/Mars vehicles

ADVANCED DEVELOPMENT PROGRAM TASK CATEGORIES - FY 89 - 90

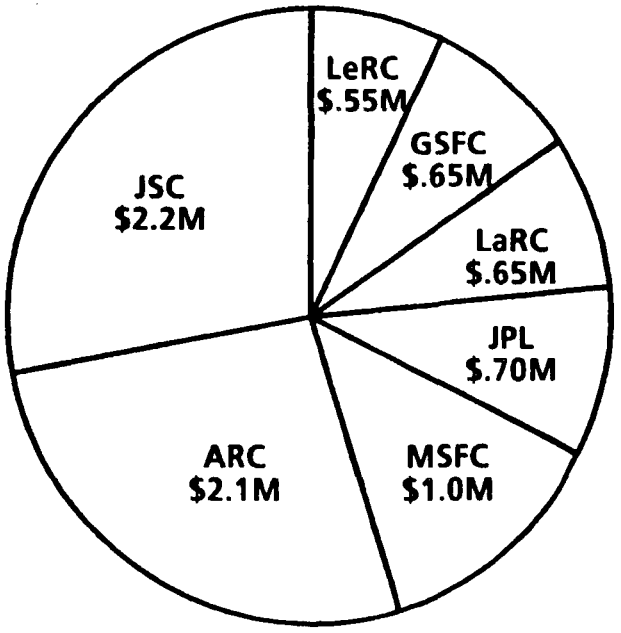
- Flight Systems Automation
- Ground Operations Automation
- Information Processing Systems
- Advanced Automation Software Tools
- Telerobotic Systems

ADVANCED DEVELOPMENT PROGRAM OVERVIEW - FY 89

FREEDOM

- 8 tasks funded in FY 88 at $1.8M
- 30 tasks funded in FY89 at $8M

BY CENTER



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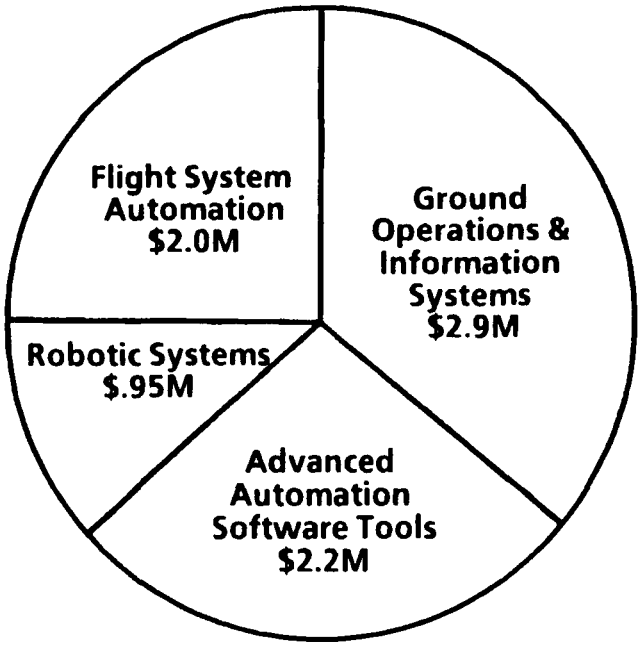

- 14 of 30 tasks leveraged; $12.5M from OAST, OSF, USAF, DARPA
  - -- MOUs/MOA's in place with OAST for Automation & Robotics
  - -- Draft MOU with OSF for advanced development in final coordination
  - -- Leverage results in $20.5M impact

OSS-11622B
2/5/90

FLIGHT SYSTEM AUTOMATION AND GROUND OPERATIONS APPLICATIONS

FREEDOM

- *Focused on Automated Status Monitoring, Fault Detection, Isolation, and Recovery (FDIR) using Knowledge-Based System (KBS) techniques*

- *Understand design accommodations ("hooks & scars")*

  -- Instrumentation, control redundancy, interfaces

- *Identify KBS implementation issues*

  -- Integration with conventional techniques
  -- Processing, data storage, communication requirements
  -- Software development, testing, maintenance
  -- Boundaries of KBS technology (performance, scale, brittleness)

- *Applications under development for Thermal, Power, Life Support, Data Management, Mission Control*

INFORMATION SYSTEMS
ADVANCED TECHNOLOGY DEVELOPMENT

FREEDOM

- *Focused on providing advanced processors, network architectures, and software development tools to prevent obsolescence and reduce power consumption & cost*

- *Enable growth, evolution of OMS, DMS, SSE infrastructure*
  - -- Extensable hardware, software architecture
  - -- Embedded fault tolerance, system security
  - -- Improved processing, memory, data storage, communication network performance
  - -- Reduce training and sustained operations costs

- *Improve software development, testing, maintenance*
  - -- KBS tools for conventional software development
  - -- Tools to develop, test, integrate KBS applications
  - -- Tools for design knowledge acquisition, maintenance

ADVANCED AUTOMATION SOFTWARE TOOLS

FREEDOM

- Focused on providing programming tools to enable development of integrated KBS applications within the Software Support Environment (SSE)
- KBS programming tools which produce Ada code are under development and evaluation
- "Programmers Assistant" that uses KBS techniques to aid programmer in Ada software re-use under evaluation
- Programming environment for Intelligent Computer-Aided Training (ICAT) applications under development

TELEROBOTICS TECHNOLOGY AND APPLICATIONS DEVELOPMENT

FREEDOM

- *Focused on demonstrating technology to improve Flight Telerobotic Servicer (FTS) productivity*

- *Understand integration of component technologies*
  - -- Common architecture for sensing, perception, control

- *Understand integration within total system framework*
  - -- "Robot friendly" design for assembly, maintenance, servicing
  - -- Operational concepts, mission scenarios for EVA/robot mix

- *Understand implications of operations with time delay*
  - -- Impact on interface, control architecture, functionality, task and worksite design

ADVANCED DEVELOPMENT PROGRAM OVERVIEW - FY 90

FREEDOM

- 8 tasks funded in FY 88 at $1.8M
- 30 tasks funded in FY89 at $8M
- 35 tasks funded in FY90 at $8.2M

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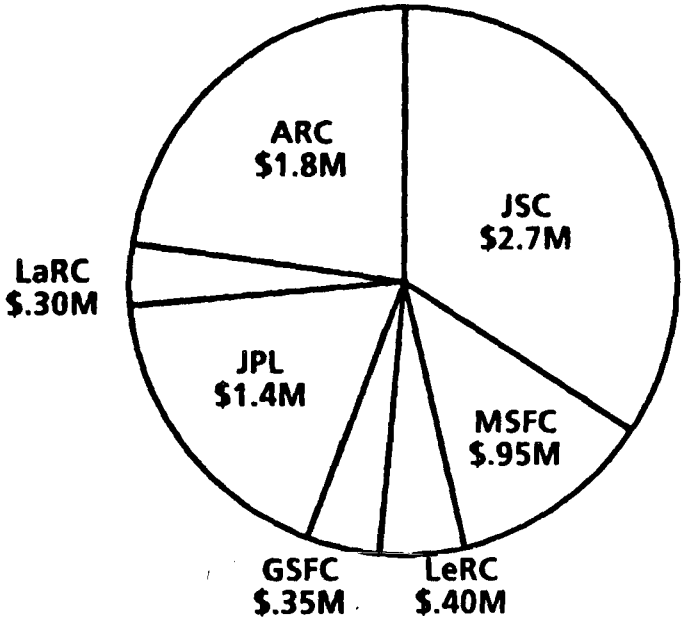

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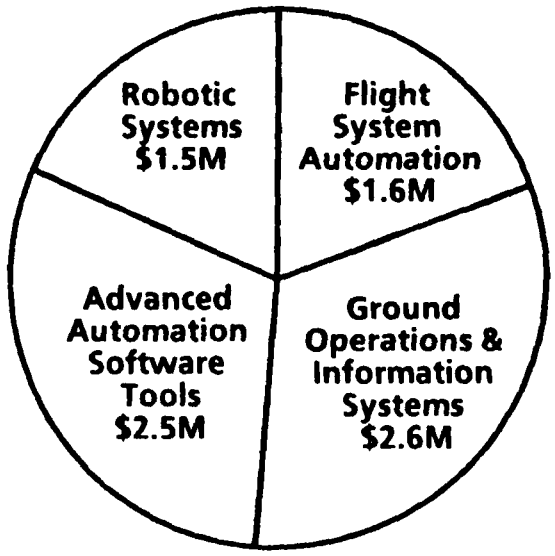
Robotic Systems $1.5M
Flight System Automation $1.6M
Advanced Automation Software Tools $2.5M
Ground Operations & Information Systems $2.6M

- 17 of 35 tasks leveraged; $14.0M from OAST, OSF, USAF, DARPA
  - -- MOUs/MOA's in place with OAST for Automation & Robotics
  - -- Leverage results in $22.2M impact

OSS-11622
2/12/90

TRANSITION DEFINITON PROGRAM
ADVANCED DEVELOPMENT - FY 1990

FREEDOM

- *Flight Systems and Ground Operations Automation Tasks*
  - -- Focused on automated status monitoring, fault detection, isolation, and recovery (FDIR) using knowledge-based system (KBS) techniques
  - -- FDIR KBS applications under development for the Thermal Control System, Power Management and Distribution/Control Systems, Environmental Control & Life Support System, Data Management System, Operations Management System, Mission Control Center (MCC), and the Space Station Control Center (SSCC)
  - -- MCC applications were jointly developed with OAST and OSF and have supported STS-26, STS-29, STS-30, STS-28, STS-34 and STS-32; all will be transitioned to SSCC

TRANSITION DEFINTION PROGRAM
ADVANCED DEVELOPMENT - FY 1990

FREEDOM

- *Information Processing Systems*

  -- Focused on providing advanced processors and network architectures which improve performance and reduce power requirements of Station computer systems; developing advanced Management Information System applications

  -- Development of a space-qualified multiprocessor is continuing; will be compatible with baseline Station and will be available for on-orbit evaluation by Permanently Manned Capability (PMC)

  -- Advanced Planning, Scheduling, and Resource Allocations tools which use KBS techniques are under development and evaluation; they enable rapid development of complex plans & schedules with few people, permit accurate real-time re-planning

TRANSITION DEFINTION PROGRAM
ADVANCED DEVELOPMENT - FY 1990

FREEDOM

- *Advanced Automation Software*

  -- Focused on providing programming tools to enable development of KBS applications within the Software Support Environment (SSE)

  -- KBS programming tool which produces Ada language software is under evaluation for incorporation into the SSE; KBS "Programmer's Assistant" that aids programmer in re-using existing Ada software is under evaluation; both tools have been transitioned to commercial sector by developing company

  -- Programming environment for Intelligent Computer-Aided Training (ICAT) applications is nearing completion; Initial Station applications will support SSCC console operator training, later use by astronauts for on-orbit refresher training is expected; Private sector funding developed and transitioned high school physics tutor

TRANSITION DEFINTION PROGRAM
ADVANCED DEVELOPMENT - FY 1990

FREEDOM

- *Telerobotic Systems*

  -- Focused on improving productivity of Flight Telerobotic Servicer (FTS) and understanding Astronaut-Robot task allocation and robot-system interface issues for evolution

  -- Computer-based analysis tool is under evaluation which assesses the allocation of tasks between astronauts and robotic systems; Tool will be distributed to Level II, FTS Project Office, and WP-02 for evaluation and use within the baseline Program

  -- Advanced control algorithms and task/spatial planning has been developed and demonstrated and favorably reviewed by Astronaut Office, FTS Project Office and Contractor; Transition to FTS Project Office in support of early demonstration flights and the baseline FTS is underway

  -- Development of operator interface, sensor fusion, and control techniques to permit teleoperation and supervised control with time delay will continue; Goal is to support ground operation of FTS while performing inspection, maintenance, & servicing tasks

SUMMARY

FREEDOM

- *Advanced Development Program initiated at beginning of Phase CID with modest funding*
  - -- High degree of leverage provided by OAST, OSF, other government agencies joint funding
  - -- Focus on automation and robotics has produced measurable results and provided early options
- *Increased funding in FY91 will expand scope, pace of tasks in preparation for post-PMC sustained operations & evolution*
  - -- Additional disciplines will be included
- *"Technology transfer is a body contact sport." - John Muratore*
  - -- People are key factor in affecting or preventing technology migration and utilization